

ESTADO DEL ARTE DEL PROYECTO: “Improving Steel Buildings Resilience through Innovative Design Strategies”

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ABSTRAC: The objective of the proposed project is to explore innovative strategies for improving steel buildings resilience through an approach that actively integrate the architectural and structural design processes. This project will be divided in two focus areas, the first phase will focus on developing the integrated architectural-structural design framework that includes a set of computational tools (both commercial and in-house developed code) to incorporate actively the structural engineering processes into the architectural design. The second focus area will deal with developing strategies to improve steel building resilience through the use of energy-dissipating strategies and facilitated by work emerging from the research plan for the first research focus area.

MARCO TEÓRICO: The research objective will be realized by focusing the efforts into two main areas: (1) methods and tools for integrated architectural-structural design of steel buildings, and (2) strategies for improving steel buildings structural resilience using energy-dissipating devices. In the first focus area, computational tools will be implemented to facilitate an integrated architectural-structural design process. A computational framework will be developed to couple high fidelity nonlinear structural analysis capabilities with a parametric architectural design package to allow pseudo real-time feedback in the design process. Frameworks such as Autodesk Dynamo [1] or GrassHopper [2] present capabilities to implement parametric geometric and structural design within the architectural design process through linking to structural analysis packages such as Robot Structural [3] or Karamba3D [4,5]. To the researcher’s knowledge the previously mentioned structural packages lack advanced simulations capabilities available in packages such as OpenSees [6], OpenFOAM [7,8], ABAQUS [9] or LS-Dyna [10] that seat at the innovation forefront of the advanced structural analysis. This project will explore enhancements to the design ecosystems to provide integrated advanced simulation capabilities including nonlinear structural analysis, structural optimization, fracture modeling [e.g., 11,12] and others within the architectural design process. This will include implementing in house developed user code and linking with some of the applications previously mentioned. In addition to computational tools, strategies and curriculum material will be developed to include basic structural engineering concepts and the use of the developed framework within or in parallel to current design courses in the architecture undergraduate curriculum. For the second focus area, strategies using passive energy-dissipating devices (structural fuses) to reduce the deformation demands in lateral-force resisting systems caused by extreme loads (e.g., seismic loads) will be explore. Using structural fuses in strategic locations of the structure concentrates most of the damage induced by extreme loads into these devices that can easily be repaired/replaced minimizing downtime for reparations making the structure more resilient [13-16]. Initially the focus will be on developing strategies to use structural fuses within floor diaphragms to reduce the shear deformation demands in the vertical lateral force

resisting system (vLFRS) and improve performance under lateral loads. Traditionally resistance to lateral forces and energy dissipation is concentrated into the vLFRS and strategies for structural fuses is often geared to these systems that are essentially thought as 2-dimensional/planar structures. Such approaches generally use simplified models for the diaphragms force flows to reduce the lateral load to be resisted in one direction without fully incorporating the 3-dimensional (3D) nature of the structure and seismic forces. Exploring energy dissipation using fuses within floor diaphragms will open opportunities to exploit the 3-dimensional/spatial nature of a building to distribute the damage accumulation and improve performance. In the proposed research, the influence of key structural properties on the seismic performance of a simplified prototype building with fuses connecting the floor diaphragm to the vLFRS. Results from the parametric study will be used to devise strategies for the fuse system's design and layout optimization.

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